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Innovation in Public Health to Reduce Major Health Risks for Developing Countries.

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Innovation in Public Health to Reduce Major Health Risks for Developing Countries.

1.0 Background

This paper is being prepared under contract to the Office of Sustainable Development and Health Environments, World Health Organization as a thought starter for the *Commission on Intellectual Property Rights, Innovation and Public Health*. The Commission focuses on intellectual property rights related to drugs, vaccines, diagnostic tools and patents. Yet, this paper will deal exclusively with two environmental health issues which have no obvious or direct connection to drugs, vaccines or diagnostic tools. Why?

Innovative solutions to problems facing developing and developed countries, whether or not they relate to public health, drugs and medical instruments, infrastructure, aid transfer, economic development, social support, or environmental protection, require innovative thinking. Progress made in finding solutions to one set of problems can be instructive to finding solutions for other problems. **Defining a problem is important; considering innovation as part of the solution is essential.**

2.0 Purpose of this Paper

We believe that there are lessons to be learned from environmental health case studies for those working in, or for, developing countries on questions related to innovations in public health, patent medicine access and intellectual property rights. These lessons have less to do with intellectual property rights *per se* than with the need for creativity with respect to devising the appropriate incentive structures for (largely non-commercial) innovation and diffusion of new technologies. As a result, we propose to briefly discuss how science, organizational awareness and innovation can foster capacity building for **two significant** environmental health issues in developing countries.

Further, a strong connection exists between some environmentally caused disease and the proactive and protective effects that can come from better public health policy and availability of medical treatment and medicine.

3.0 Global Environmental Health Risks

The human toll associated with environmental health causes is staggering. The WHO and UNEP (WHO/UNEP, 2005) has recently reported that globally and annually:

- 1.7 million people die from poor sanitation, hygiene and degraded water quality;
- **1.6 million people die from respiratory disease associated with exposure to indoor smoke from solid fuel use**
- 1.2 million people die from malaria associated with insect vectors which are sustained through losses in biodiversity, water storage, waste management and irrigation practices, and deforestation;
- 1.2 million die as a result of road traffic injuries related to poorly unplanned changes in the built rural and urban landscape attempting to accommodate growing populations;
- 0.8 million people die from polluted urban air;
- 0.4 million people die from toxic exposures to pesticides and industrial chemicals at work or at home;
- 0.2 million people die from exposure to lead; and
- **0.2 million people die as a result of climate change and its impact on agriculture, severe weather events and disease vector migration.**

In general, more than 90% of these 7.3 million annual deaths are associated with the poor and those living in developing countries. Environmental factors have been estimated recently as the cause of 25% of global deaths (Smith et al 1999). The cultural, social and economic losses suffered as a result of disability and lost quality of life for those who survive is probably an order of magnitude higher.

It is within this context that we have chosen to examine how innovation can be applied to reducing risks and deaths and mitigating suffering for two environmental issues:

- climate change - a continuously emerging health issue; and
- indoor use of solid fuels - a deep rooted existing health and environment issue.

4.0 Issue A. Climate Change and Health

4.1 Health Risks

Global temperatures are increasing at a rate ‘unprecedented in the experience of modern human society’ and the earth’s climate is changing. While natural and physical events and cycles have resulted in significant global climate change in the past, the rapid change now underway can be clearly ascribed to human activity. Emissions of carbon dioxide and other green-house gases are the drivers of this change.

Concurrent with climate change sequelae (e.g., temperature and precipitation changes, severe weather, rising sea levels and habitat alteration) is increased human exposure to ultraviolet (UV) radiation because carbon dioxide interferes with the recovery of the upper atmospheric ozone

layer (ACIA, 2004). In addition, heat waves and air pollution, directly attributable to climatic conditions, air pressure and wind patterns, can cause considerable ill health and loss of life (WMO, 1999).

McMichael et al (1998) have estimated that an increase of 2.5 C over the next century, predicted by the Intergovernmental Panel on Climate Change, will give rise to a 6 fold increase in the global population at risk of water shortage, a 3-fold increase in those at risk of hunger and a two-fold increase in those at risk of malaria (see Appendix I for details of specific effects that have been predicted). **For climate change related health risks, the question is not ‘when should we adapt?’... it is, ‘how will we adapt?’.**

4.2 Reducing the Risks

Climate change is a world-wide phenomenon that affects rich and poor, urban and rural populations, young and old. International, national, regional and local strategies are needed if we are to successfully adapt to, and manage, the risks. These must be supported by funding, incentives that are applicable to developing countries, functioning institutions and legal instruments that support actions.

Reactions and solutions will vary according to the credibility of the predictions, political will, cost and acceptability of the mitigation. North–south differences in reaction will vary in part because the northern Hemisphere may feel a greater impact of climate change than the southern Hemisphere (Leiss et al. 2001), the health risks will have different dimensions and the economic capacity to deal with change is orders of magnitude different between the hemispheres.

In general, responses to climate change are mitigative (intended to slow the rate at which climate change will occur) or adaptive (designed to alter lifestyles, products and practices to protect property, economy and people). Mitigative solutions tend to address upstream aspects of climate change, i.e., the fundamental cause of climate change, green-house gas production. Adaptive solutions tend to address downstream aspects of the problem, i.e., the effects of climate change on agriculture, permafrost, wildlife, human populations, disease vectors, etc.

4.3 Innovative Strategies

- Global problems require global action. The development by the international community of the Kyoto Protocol on Climate Change within the existing Montreal Convention was a first step at developing a global action plan and targets for reducing greenhouse gas (GHG) emissions. By coming to an agreement, the global community has bought ‘adaptation time’. Meeting the targets will not reduce risks in the short term; however, if implemented, it will slow the rate of temperature change globally such that human adaptation will have a greater chance to succeed.
- Over the longer term, changing energy technologies offer the opportunity both to reduce air pollutant emissions and the attendant health risks and to address climate change

issues: “The long-term energy future must be both affordable and characterized by near-zero emissions of both air pollutants and greenhouse gases” (Goldemberg et al., 2001).

- Emissions-trading has become a large part of some national strategies for meeting GHG reductions. The ‘emissions’ are traded (bought and sold) as commodities between registrants in an accessible, monitored and verified international database. Some governments also maintain domestic registries under similar rules so that as much internal trading as possible can take place and can be tracked. Registrants can be industries, communities, and individuals in some schemes (e.g., Canada). This is the first time that global trading in pollution has been enshrined in a Multilateral Environmental Agreement.

- Government subsidies directed at research on renewable energy (wind turbines, electrically supported heat pumps, solar energy, biomass fuels) and corporate visibility for alternative energy products (see box on

Innovation: The city of Calgary, Alberta has dedicated wind generated energy as the source of power for its rapid transit train system. More wind generated power is being developed to keep pace with the expansion of the system. This demonstration of public and governmental commitment to reduce use of fossil fuels in an oil and gas rich region also provides technology stimulation, public encouragement for use of clean mass transit, reduces the need for personal vehicle transportation (and pollution/congestion) in the urban area, and is equitable for the range of income earners (subsidized transit fares).

wind energy electric light-rail in Calgary, Canada) are being used to stimulate and demonstrate market innovation.

- National governments of developed countries have created a variety of positive incentives (reduced pricing or taxation for fuel efficient and low emission vehicles) and negative incentives (vehicle emissions testing, increased corporate taxation, fines for polluters, urban core taxes for vehicles) to reduce domestic emissions.

Innovation: London, U.K. and Stockholm, Sweden have instituted a tax/permit system for vehicle use in the city centre to reduce congestion, pollution and promote rapid transit. The spin-offs include better health, less GHG production and higher tourism.

- Dialogue on, and measures for, home and corporate building energy conservation (lower building temperatures, low energy illumination systems, better insulation, reflective thermal barriers and materials, heat recovery ventilation systems, altered building codes) have also had some success at reducing fossil fuel demand and maintaining safety and comfort. These are mitigative actions.

Innovation: In order to reduce energy consumption and GHG emissions, Japanese business men are being encouraged to wear more casual summer clothes rather than dark business suits this year as companies set their air conditioner at 28 C. The Chairman of Toyota Motor has agreed to model the casual clothes and to refuse to meet with any colleagues wearing suits. Cultural change takes leadership.

- Pricing (higher manufacturing cost or taxation increase) is the most powerful tool for reducing consumption in developed countries; however it is less likely to be used as a tool in an unstable political and/or economic climate for fear of voter backlash. Many of these incentives are of little value in poor countries where most cannot afford to purchase energy and will turn to cheap, polluting, solid fuel sources that weaken the environment and directly harm respiratory health.

Innovation: Air pollution forecasts in Europe and North America are being used to warn hospitals to expect higher patient loads due to respiratory health distress. Better preparation leads to lower health care costs, more effective patient care, and less mortality. This is an adaptive response.

- Weather system prediction (meteorological forecasting) on a seasonal basis is now being used by the WMO to aid disaster prevention and save lives from future severe weather events.

- Bioclimatology scientists are working to establish relationships between climatic periods (temperature and humidity), weather events and human exposure to insect and microbial vector outbreaks (mosquitoes, moulds) and airborne pollution events (pollen and spore counts, particulate levels).

- Some regions are now routinely stockpiling vaccines, food and shelter supplies in anticipation of severe weather events. This approach can also reduce deaths significantly and enable a community to normalize functions more rapidly.

Opportunity: Major drug manufacturers and medical suppliers could twin with municipalities or regions in developing countries where severe weather events are likely to be most damaging and offer low cost/no-cost supplies

- Early warnings systems for high temperature episodes, air quality exceedences and high UV exposure days are in use in many countries but are only rudimentary in most developing countries, even though they can markedly reduce hospitalization and premature death. For similar reasons, several developed countries advertise when to reduce outdoor activity during severe heat and air pollution episodes. These types of warnings are rarely an option for the poor in developing countries as their employment is frequently outside and there is little economic buffer for a day of lost wage.

Innovation: ‘Slip-slap-slop’ (slip on a shirt, slap on a hat, and slop on UV blocker) has been an effective marketing slogan for children, mothers and primary school teachers to promote adaptive behaviour change in Canada as UV exposures increase in level and duration.

- Public health agencies and offices promote risk reducing behaviour through education and awareness programs aimed at workers, mothers and children and youth. Protective head gear and skin covering is effective for UV protection. UV blocking creams can reduce the risk of skin cancer and shaded eye wear can reduce glare and cataracts. These are adaptation techniques.

Innovation: In 1971, under the leadership of a newly appointed mayor, the city of Curitiba, Brazil began an ambitious effort to integrate land use planning with a transportation policy that emphasized quality, affordable mass transit and dedicated transportation corridors. This enabled the city to minimize congestion and provide relatively high levels of mobility, even as its population grew from 600,000 in 1970 to 1.6 million in 2000. Seventy-five percent of travel within the city is via the city's buses-only transit system. The system has become a model that is studied worldwide, and was one of the inspirations for the Institute of Transport and Development Policy's International Bus Rapid Transit Initiative, launched in 2001 (Rabinovitch, 1996; Leahy, 2002; Macedo, 2004 and <http://www.itdp.org>).

- Urban planning -- specifically, to reduce reliance on private automobiles for transportation and ensuring compatibility of land uses with public transportation -- can contribute to 'win-win' outcomes (see e.g. Newman, 2000; Hook and Wright, 2002). Benefits include: reducing greenhouse gas emissions from vehicles; reducing urban outdoor pollution levels that would be regarded as health emergencies if they occurred in the industrialized world; reducing traffic injuries and deaths, many of which occur among people too poor to be vehicle owners; reducing the destructive social exclusion, which may itself have direct and indirect health consequences, that accompanies limited mobility. Compare the success of Curitiba, Brazil (see box) with the failures of land use and transportation policy in São Paolo, Brazil and throughout urban India (Alcantara de Vasconcellos, 2005; Pucher et al., 2005).

Innovation: A method of rapid economic valuation undertaken at the local level with local leaders has also been effective for developing concrete action one community at a time (WHO/UNEP, 2005)

- Insect vector sterilization programs may be effective in reducing the expansion of the range of vector species that may find new habitat suitable with climate change. The spread of screwworm in Central and North America has been controlled by sterilizing and releasing male screwworm flies. Ultimately it is hoped that a sterile fly barrier can be maintained at the Darien Gap between Panama and Columbia.

Opportunity: Mexico has combined research on the lifecycle of mosquito vector species across the country with community education and action (to drastically reduce standing water where mosquitoes breed), targeted pyrethroid sprays, bed nets and rapid medical treatment for malaria, to reduce the infection reservoir. DDT use ceased in 2000. Only a few malaria cases are reported a year! (CEC, 2003). Could Africa use this approach to reduce current insect vectors and the spread of vectors with changing climate?

- Local adaptation intervention programs focus primarily on quality and consistent education and community dialogue led by those who are trusted in the community such as elders, public health professionals, teachers, and local scientists. Local action often centers on greater preparedness facilitated by an informed and empowered community, improved infrastructure codes, more rigorous site approvals (for upgrading

transportation, shelter and safety) and clean-up, better flood management preparation, and through disaster relief planning, e.g., communications networks, food, water, medicine, clothing, beds, shelter, generators, heavy construction equipment, building supplies and tools.

4.4 Research Gaps

Research on climate change has been extensive and continues to be vigorous in developed countries and international bodies. Its thrust has been predictive: estimating the changes in regional climate and temperature as GHG levels increase; estimating impacts and locating probable impact zones; weather event prediction (long range, seasonal and weekly); and mechanisms for international action to reduce GHG releases. Despite the sophisticated state of the modeling published to date and the verification of many of the major short term predictions, the international community is not in full accord and some major players have not ratified the Kyoto Protocol because of the financial implications of ‘unproven’ long-term predictions.

In developing countries, there has been little focus on climate change research and little apparent development of strategies to mitigate the effects of climate change. This is not surprising. Out of necessity, poorer countries are focusing on agricultural science to enhance self sufficiency and on improving disaster mitigation. Predictive science is likely to get less attention than science that can translate into economic value.

It would be useful for international organizations and national aid research groups to support climate change response research in developing countries. Research investment through cooperative government-to-government ventures would benefit practical needs in affected countries (e.g., research on infrastructure needs, early warning of bioclimatic events and severe weather, disaster prevention, planning for greater rural to urban migration, etc.) and develop lasting capacity among governmental and university scientists and policy makers. Research in ‘integrated policy development’ for climate change would also build capacity and provide additional environmental and economic benefits beyond mitigation itself (WHO/UNEP 2005).

Opportunity: The Health and Environment Linkages (HELI) project launched by Canada at the World Summit on Sustainable Development in 2002 matches countries with expertise and those needing expertise. It is a low cost, science based program operated through the WHO to make scientific data more accessible, promote policy development and build capacity on issues of concern to developing countries or regions. It also avoids the issue of intellectual property rights as the literature reviewed is openly available and policies are made-at-home in the developing country. (WHO/UNEP 2005)

It would also be useful for such groups to coordinate support for research on new, environmentally benign energy technologies and – perhaps even more importantly – to ensure that today’s best technologies and tomorrow’s are available and affordable to developing countries, which “have the chance to leapfrog over many of the dirty and wasteful processes that industrialized countries adopted because of the limits of technology at the time” (Goldemberg et al., 2001). However, adoption of such ‘clean’ technologies is inhibited – as it is in the

industrialized world – by their frequently higher initial cost and the lack of financing mechanisms that take into account potential long-term cost-savings (e.g., from energy-efficient buildings and industrial processes and from lower hospitalization and health care costs).

4.5 Acceptability Factors

The acceptability of mitigation strategies, whether under consideration by a government or an individual is often reduced to three fundamental questions:

....is this relevant for me (us);
....can I (we) afford to act; and
....can I (we) afford not to act?

Public participation in development of solutions is essential for acceptability, which underscores the importance of honest consultation. Jurisdictions must ensure that they have the authority to act and to coordinate their actions to make solutions effective (see box)

Valuation exercises which assess both benefit-cost and net benefit are essential for evaluating the response to the questions above.

Unfortunately, climate change is one of many pressing issues requiring an

analysis of relevance. It must compete with other pressing public health, economic and social needs. Currently, climate change is likely to come below disease treatment (HIV/AIDS, polio, encephalitis, availability of medicine), disease prevention (including vaccination) and sanitation, distribution of fresh water, vaccination and availability of medicine, childhood development and education.

Innovation: “When New York City’s water quality was threatened by increased bacterial and agricultural pollution, an economic valuation estimated that a **managed ecosystem approach to the protection of the ...watershed** could restore natural filtration mechanisms protecting the city’s water quality and health – at about one-sixth of the cost of a modern water filtration plant. The city chose to adopt this approach, financed by **new user fees** for water and a package of **economic incentives** for the watershed land owners and communities to employ better land use management.

These measures were effective because they were supported by **legal tools**, permitting the state to control land use in the watershed area, alongside **social action** that raised awareness about the importance of watershed protection.”
(WHO/UNEP, 2005)

4.6 Equity Issues

Responses to climate change raise equity issues both within and among nations. Among nations, most of the largest greenhouse gas emitters are high- or at least middle-income countries, which will suffer only modest negative consequences and have ample resources for mitigation, adaptation, and longer-term investment in new energy technologies. Low- and middle-income countries may legitimately wonder about the demand that they adopt expensive solutions to greenhouse gas emission reductions if the technologies needed are not made available on concessionary terms (one of the few areas discussed in this report to which intellectual property rights may be directly relevant).

Developing countries must not be called upon to divert any of their already inadequate resources for health care and other basic needs to climate change mitigation and adaptation. Within nations, it is conceivable that many costs of mitigation, adaptation and greenhouse gas emissions, as well as the health risks associated with climate change, will be borne primarily by those least able to afford them. WHO's recently established Commission on the Social Determinants of Health may wish to turn its attention to some of these issues given its strong conceptual emphasis on health equity – and, conversely, the potential for 'win-win' situations in which health risks are reduced in tandem with the achievement of other social and economic benefits.

5.0 Issue B. Indoor Smoke from the Use of Solid Fuels and Health

5.1 Health Risks

According to the WHO, 2.7% of the global burden of disease is caused by indoor air pollution (see Appendix I for details of specific effects that have been predicted). The source of this disease catastrophe is the indoor burning of solid fuels in open fires or traditional stoves for cooking and heating. According to the latest assessment of the Millennium Development Goal indicators, more than 3 billion people worldwide, half the global population, depend on wood, peat, animal dung, straw or other compacted carbon-rich agricultural waste (biomass fuels) and coal (fossil fuel) as their energy supply. These fuels produce indoor levels of carbon monoxide, soot, and fine particulates that frequently exceed air quality guidelines 20-fold.

5.2 Reducing the Risks

Several solutions have been tested and have had varying degrees of success. Success factors are complex because the solutions needed are required for a vast cross-section of the global population and a vast cross section of cultural tradition, beliefs, and social interaction.

First and foremost, to be adopted and maintained by users, interventions must meet the cooking and heating needs of users as well or better than traditional cooking practices. Sustainability (including aspects such as that equipment solutions must be available, reliable and repairable) critically relies on interventions that are tailored to the local situation and socially acceptable by women and men alike. Designing and installing interventions with full community participation and users' contribution - in money or in kind - for the technical solutions are a good way of ensuring sustainability. To be effective in reducing health problems, interventions must substantially reduce indoor air pollution levels and provide knowledge about hazards and how to avoid them. In addition, financial savings or reduced fuel gathering time may be major incentives for households to adopt and use interventions, and can open up opportunities for education and income generation. Some interventions may also provide better light for evening activities that

may be income generating (sewing, schooling). Given the complexity of the problem, it is therefore not surprising that as Bates et al. (2005) point out: “Despite a large number of small-scale studies looking at the levels of indoor air pollution in poor households, the number of successful initiatives to reduce the burden of ill health is relatively small in comparison to the scale of the problem.”

5.3 Innovative Strategies

A) Technical solutions

- Venting smoke more effectively can reduce exposure, however, as of yet it is not clear whether relatively small reductions in particulate matter have noticeable benefits for women's and children's respiratory health. Cooking windows or fume cupboards are in use in parts of Africa to vent away the majority of the dangerous smoke and gas from open biomass cook stoves. These have good acceptability, but do not reduce fuel gathering time. Windows must be reasonably small in some communities for privacy and to limit wild animal entry.
- Improved stoves must reduce emissions to result in lower indoor air pollution levels, and increase fuel efficiency to reduce fuel consumption and thus the need to collect or purchase fuel. A ceramic chimney-less stove which uses less biomass fuel by enclosing the heat, burns more efficiently and with less smoke, heats more quickly and produces about 50% less indoor smoke has been used in Africa. It is made locally, has a reasonably good life use, meets traditional needs, and cuts down on fuel searching time marginally (WHO, 2000). Insulated, so-called “rocket” stoves (Bates et al., 2005) for burning wood are notably effective.
- Other strategies to reduce the level of indoor air pollution have focused on the use of solar energy in the preparation of food. A wide variety of inexpensive and easily manufactured designs have been proposed for these ‘solar cookers’, which require about 20 minutes of sunlight each hour to be effective. As these cookers are used outside the home, any hazard of indoor pollution from the burning of biomass fuels is removed. These units have also been proven to be effective in the pasteurization of contaminated water (Ciochetti & Metcalf, 1984) and the disinfection of biomedical waste (Chitnis, Chitnis, Patil & Chitnis, 20003). The uptake of this technology has been somewhat limited however, owing to concerns of privacy and sanitation. Furthermore, the reliance on solar energy mandates that food must be prepared during the day, a restriction that does not always accommodate the cultural norms of the community.
- From a health point of view, switching to cleaner fuels is the best alternative. Traditionally available fuels are kerosene and Liquefied Petroleum Gas (LPG). Kerosene stoves are efficient and, if well adjusted, burn with a clean blue flame and high heat. Availability of kerosene stoves or LPG burners, maintenance, availability of kerosene or LPG, income to buy fuel and acceptability of cleaner fuels are issues which affect the uptake of programs.

- Some "new generation fuels" can meet health as well as environmental criteria. Producing and burning cleaner bio-fuels can eliminate smoke production and fuel gathering time. Biogas (generally methane) has been successfully generated from animal dung and water where there are adequate amounts of both. Other plant based fuels like ethanol can be created from fermentation of vegetation, sugar cane or rapeseed; however there is a barrier in acceptance of alcohol in some communities. Some experimentation with alcohol based gel fuels may provide an alternative. In addition, novel technologies for the use of canola and castor oil plants in indoor cooking are currently being developed by Bosch Siemens, in cooperation with German development agencies. These oils are renewable, biodegradable, safe to handle, and are carbon dioxide neutral. The by-product of the oil processing can also be used a high-quality fertilizer in supplementary agricultural applications. All these fuels are clean burning but may be in short supply if drought limits any of the precursors.

B) Strategies

- Stimulation of demand and targeted subsidies to families for fuel and stoves appear to have more potential for success than generic subsidies for fuel supplies. Fuel subsidies over the long term can benefit primarily the affluent: Brazilian experience, for instance, showed that subsidized LPG was being used for swimming pool heaters and saunas (Lucon, Cuelho and Goldemberg, 2004; Goldemberg et al., 2004).
- Supporting a product development, distribution and maintenance industry in local areas which can generate income locally and be sustainable is essential. Capital investment is difficult to obtain for the development of low-cost equipment for which there is limited economic return for investors, manufacturers, distributors and repair shops.

Innovation: The European Commission has proposed an airline tax in Europe of 1 euro/passenger which could be used to alleviate poverty disease and hunger. Could such a fund be used to stimulate development of local industries to design, build, market and maintain clean fuel and clean burning stoves?
- The implementation of interventions that address numerous environmental and health-related endpoints is a judicious use of limited resources in developing nations. In Nepal for example, a high demand for fuel wood has contributed to the rapid increase in deforestation, soil erosion and landslides. In addressing this problem, the Nepalese government has worked with local banks to subsidize the construction of domestic biogas systems. These fixed-dome plants are used to collect animal dung, human wastes and crop residues and convert them into biogas via anaerobic digestion. The biogas fuel can then be used for lighting, cooking, and electricity generation without contributing to indoor carbon dioxide or sulfur emissions. An overall improvement in the health profile of the household may then be realized, as the use of cleaner indoor fuels such as biogas has consistently been associated with a decrease in respiratory disease (Bruce, Neufeld, Boy & West, 1998; Shrestha & Shrestha, 2005; Smith, 2002). The sanitation of the household is also improved, as human and animal feces are suitably disposed of into the biogas plant (Sahlstrom, 2003). Another desirable output of the biogas plants is the waste

product from the fermentation process, which may be removed from the plant and applied to the agricultural system as a nutrient-dense fertilizer. The socioeconomic profile of the household is also improved, since women who traditionally bore the responsibility of collecting firewood are now afforded more time to pursue income-generating activities for the household. At the macro-economic level, the government of Nepal is able to sell their conserved carbon credits to more developed countries that regularly exceed their quota for carbon emissions. The profit generated from the sale of carbon credits is then reinvested into the construction of more biogas plants. In summary, a project involving public, private and individual stakeholders has significantly improved the environmental, socioeconomic and health capacities of rural dwellers in Nepal.

- Resource Efficient Agricultural Production Canada (REAP-Canada) has received international acclaim for its development of holistic bioenergy programs. With support from the Canadian International Development Agency (CIDA), a low cost and clean-burning stove that uses rice hulls for fuel has been effectively deployed in the Philippines and the Gambia. The near-ubiquitous availability of rice hulls in these countries (in addition to other agricultural residues such as cocoa and peanut shells) has facilitated the displacement of traditional indoor air pollutants such as wood and charcoal by as much as 100% in some regions. The net effect of this substitution are significant decreases in indoor smoke and suspended particulates, time demands for fuelwood harvesting, household fuel costs, greenhouse gas emissions and deforestation. Countries that use the technology are also eligible to receive carbon credits under the Clean Development Mechanism of the Kyoto Protocol.

5.4 Research Gaps

Epidemiological tools are essential in elucidating the potential health risks from indoor air pollution. However, these measures have been criticized for having poor control over confounding variables, and difficulties in quantifying the exposure and outcome. Of the numerous methods available in epidemiological surveillance, Rehfuss (2005) describes three types of indoor air pollution assessments that may be most useful in field research: physician-based assessments, feasible quantitative assessments, and qualitative assessments. When the cases of interest are in close proximity and the sample size requirement is low, physician-based assessments are most suited for describing the relationship between the exposure and outcome of interest. More typical however, are quantitative assessments that survey persons across a wide geographic range. For these studies, sample size requirements are generally greater, and recall biases are more likely to be introduced into the study. When the assessment does not easily lend itself to quantitative reduction, such as in the development of interview tools, qualitative assessments may provide information that is most relevant to local stakeholders. These three methods may be employed in various combinations to address the following research gaps:

- Research on specific effects on the immune system and cancer, cataract formation and perinatal mortality is useful but does not affect the singular importance of immediate action to reduce the current suffering and death.

- Research is needed on whether or not intervention strategies work. Do they reduce exposures, improve the health and well-being of children and women and do they provide time for other income generation?
- Evaluations of quality control mechanisms are needed to support indoor air pollution initiatives. There is considerable interest in how new technologies for reducing indoor air pollution should be certified. And if certified, how would these policies be enforced?
- It also would be useful to focus research on how intervention strategies can be optimized. Case study follow-ups should continue to examine community participation rates and reasons, community leadership factors (elders, mothers, or other adults), successful financing approaches, acceptability of alternatives, repair and maintenance approaches, and fuel safety.
- Additional research into the cost-effectiveness of interventions is required. For example, what is the cost threshold at which an individual will adopt the new technology?
- Longitudinal studies of interventions to reduce indoor air pollution typically provide more useful information than may be obtained in cross-sectional designs. These questions may relate to the long-term health profile of a family that adopts the new technology, or using survival analysis to predict recidivism in the choice of indoor fuel. In either case, the inclusion of a temporal variable may reveal pertinent information that would not be observed when measures are taken at a single point in time.

Bates et al. (2005) note the importance of developing standardized tests to ensure that stoves being promoted actually do reduce indoor air pollution, both in the laboratory and in the conditions under which they are actually used.

It is also important that aid agencies which support programs to provide new stoves or support fuel substitution maximize the opportunities to simultaneously reduce indoor pollution, reduce pressures on the environment, alleviate poverty and improve quality of life for users. Specifically, benefits that are secondary to reducing indoor air pollution may be realized by reducing the time and effort spent by women and children in gathering fuelwood. Goldemberg et al. (2004) have previously detailed the threat to educational advancement among children who are kept from school because of the need to gather fuel. They conclude that “making small amounts of clean fuel available is a highly leveraged mechanism for relieving poverty” and provide further evidence of the availability of win-win outcomes.

Opportunity: Goldemberg et al. (2004) have called for a Global Clean Cooking Fuel Initiative “to bring about a worldwide shift to clean fluid fuels for cooking and heating in 10-15 years’ time – with an emphasis on providing clean fuels to the poorest households,” potentially modeled on the Brazilian experience with LPG (Lucon, Coelho & Goldemberg, 2004). The authors emphasize that such a program would contribute to achieving all the Millennium Development Goals (MDGs). National governments are called upon to create appropriate timetables and implementing agencies; international policies are needed both to attract private foreign investment and mobilize development assistance agencies to make clean cooking fuels a priority. Clearly, emphasis on the health, poverty reduction and gender empowerment benefits of such an initiative is important for purposes of generating the necessary support: clean cooking fuels and the stoves that burn them are just not as ‘sexy’ as, for example, large scale electrification projects.

5.5 Acceptability Factors

Gender may also be an important factor, as prevailing norms in some households and communities may mean that male members decide whether and when new, less polluting stoves or fuels are to be used. Since men spend much less time in the cooking area and are exposed to less indoor air pollution, it may be difficult to gain their acceptance, i.e., they don’t see and understand the problem

5.6 Equity Issues

As noted, programs to increase the adoption of cleaner-burning stoves and cleaner fuels can generate multiple positive outcomes for health equity: direct poverty reduction, reduction of health risks, gender empowerment and expanded educational opportunities. As in the case of climate change issues, this suggests that they should be considered by the Commission on the Social Determinants of Health.

6.0 Conclusions: Linkages to the Work of the Commission and the World Health Organization

For the most part, intellectual property rights are unlikely to present either a significant barrier or a significant incentive for research, development and technology diffusion in the areas addressed in this report. This is because many key innovations, in areas such as urban planning or liquid fuel adoption, are institutional rather than technological and not patentable. Historically, research and development dollars were unlikely to be attracted to innovations that were potentially patentable, such as improved cookstoves, because the potential market was not sufficiently lucrative. However, a renewed focus on corporate social responsibility and the use of established development and distribution systems have allowed many of these products to flourish. In particular, Philips Research and Bosch Siemens have formalized in corporate policy

their commitment to developing intermediate-level technologies and social investments in emerging economies. This commitment has facilitated the production of technologies in local industries that operate on a cost-recovery framework, such as solar box cookers and biogas plants. These projects lend further support to the notion that the use of standard market mechanisms may best ensure the quality and sustainability of such interventions. Further research is needed on whether this proposition is empirically supported.

Beyond these observations, a number of generic crossovers exist for the *Commission on Intellectual Property Rights, Innovation and Public Health* and for the WHO.

1. Innovation in public health will require **the twinning of expertise between developed and developing countries**, whether through government, corporations, research and education centers, charitable organizations or international organizations. Sharing expertise and creation of regional and local solutions will promote solutions that fit for the cultural fabric and situation of the region. It will also build sustained understanding and capacity among the participants.
2. Innovation in public health will require **multidisciplinary communication among researchers and practitioners** from a variety of disciplines and subject areas. We observe in the course of research for this report, for instance, that citations of the health and health policy literature are infrequent in articles on transportation and land use planning or sustainable energy use, and *vice versa*. People working in these various silos urgently need to talk to one another, and collaborate on specific research, development and policy initiatives (cf. Ezzati et al., 2004) Both for this reason and because of the important economic development and health equity dimensions of the topic areas addressed here, the Commission on Social Determinants of Health may provide a useful forum.
3. Innovation in public health will require **local buy-in**. Solutions created outside the region are unlikely to be successful no matter how innovative because they are unlikely to be acceptable, culturally sensitive, or seen as belonging to the community. The ideas must be developed with inside-the-region-partners who can take ownership and advocate for the action. Outside solutions cannot be sustained.
4. Innovation in public health will require **funding**, at a time when some aid agencies appear to work under more and more restrictions and charities find it harder to get core funding support for public health initiatives. Increased taxation as a vehicle to raise funds among developed nations is less and less acceptable as these countries either have high taxation rates now (Europe) or are moving to reduce taxes (North America) to stimulate the economy and solidify political power. Taxation in developing countries is not very successful due to many factors (poverty levels, corruption, methods of collection and enforcement). Small micro-funds created through a ‘luxury activity tax’ (collected by luxury hotel chains, or from airline passengers) may be considered fair and serve to enhance innovation research and alleviate suffering.
5. Innovation in public health will urgently require **greater intersectoral and interagency coordination in the provision of development assistance** (cf. UN Millennium Project, 2005) if the ‘win-win’ outcomes referred to in this report are to be achieved, and the drain on the resources of developing countries created by the need to meet multiple administrative and

reporting requirements is to be reduced. Public health agencies need to be galvanized now by the potential for rapid disease spread as insect vectors expand their range due to climate change. Similarly, desertification in one region may directly affect the health of people in another region as wind storms transport small particulates from one region to another. Public health agencies therefore need to think globally and make the linkages necessary to mitigate these risks.

6. Innovation in public health will require **a focus on awareness and education**. Awareness of the public health problem will form the base for acceptance of intervention. Education will help build the need for public health innovation. Both will support sustainable solutions.

7. Innovation in public health will require **direct work with community leaders and affected subgroups**. Elders, local councils, mothers and workers must be involved in developing and communicating innovative public health solutions or they will be rejected.

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Appendix 1: Health impacts of climate change and the use of indoor biomass fuels

A. Climate Change and Health

Global temperatures are increasing at a rate ‘unprecedented in the experience of modern human society’ and the earth’s climate is changing. While natural and physical events and cycles have resulted in significant global climate change in the past, the rapid change now underway now can be clearly ascribed to human activity. Emissions of carbon dioxide and other green-house gases are the drivers of this change. Concurrent with climate change sequelae (e.g., temperature and precipitation changes, severe weather, rising sea levels and habitat alteration) is increased human exposure to ultraviolet (UV) radiation because carbon dioxide interferes with the recovery of the upper atmospheric ozone layer (ACIA, 2004). In addition, heat waves and air pollution, directly attributable to climatic conditions, air pressure and wind patterns, can cause considerable ill health and loss of life (WMO, 1999).

Climate change is inevitable. Even if nations could eliminate all greenhouse gas emissions immediately, the current levels of atmospheric gases would influence temperatures upward for several years. However, over time, significant reductions in greenhouse gas emissions, beginning immediately, would slow the rate of change now underway. And with a slower rate of change, human population have more time to adapt socially, culturally, and economically and health impacts can be managed more effectively.

While global temperature will continue to rise, climate change will vary from region to region. Some areas will become more arid as a result of less precipitation and higher mean temperatures (e.g., the mi-west of the USA, southern Canada, Saharan Africa, central India); other regions may become wetter and cooler (e.g., Labrador in eastern Canada). Forecasting and analysis of climate change scenarios does indicate that for some temperate regions, climate change may be economically and socially beneficial. Longer growing seasons, increased tourism, increased natural resource availability, and less energy consumption are all possibilities for temperate regions. For most regions however, climate change is on balance, negative.

Changes in the Arctic region are especially problematic. To date, temperature change has been at double the rate of the global average. Melting of the polar ice cap will lead to a steady global rise in sea levels. Sea water will inundate some small island states, salinate estuaries that now are used as sources of fresh water, contaminate near-shore sub-terrainian water supplies, and render arable land infertile. In addition, as super cooled Arctic water increases in temperature, surface and deep-dwelling ocean currents will change course, speed and depth, affecting micro-climates around the world and weather events. Complex and rich food chains, many of which serve as a source of nutrition for human populations and resident and migratory wildlife, will be altered in the Arctic and oceans nearby. Changes in the ice cover and snow, permafrost, tree-line, and vegetation will: affect housing; transportation (on roads on land and ice); migratory land-species diversity; species range; accessibility of traditional food; and the spread of disease through invading microbial and vector species.

In many hot developing countries, climate change pressures will: reduce access to fresh water, quality drinking water and firewood; hinder growth of crops and livestock; displace soil, vegetation and wildlife; and contribute to increased poverty among rural and regional economies. Health risks and deaths will inevitable rise. McMichael et al (1998) have estimated that an increase of 2.5 C over the next century, predicted by the Intergovernmental Panel on Climate Change, will give rise to a 6 fold increase in global population at risk of water shortage, a 3-fold increase in those at risk of hunger and a two-fold increase in those at risk of malaria.

For climate change related health risks, the question are not ‘when should we adapt?’, it is, ‘how will we adapt?’.

Key Health Impacts of Climate Change on Hot Developing Countries

Direct:

- Increased heat related illness and death due to extreme temperature episodes.
- Increased deaths, injuries and psychological trauma associated with more frequent severe weather events such as cyclones, floods, wind damage.

Indirect:

- Higher rates of infection and death from insect vector-borne diseases such as malaria, dengue fever, yellow fever, etc.
- Increased malnutrition related deaths and adverse childhood development due to adverse growing conditions for crops and livestock, increased pest species and numbers, and severe weather events.
- Increased death and illness from lack of water, sanitation, and spread of infectious and diarrhoeal disease.
- Increased respiratory morbidity and death associated with elevated air pollution from industrial and automotive particulates, dust, pollen, spores and gases.
- Community displacement and socio-cultural degradation due to severe weather events, infrastructure damage, sea-level rise, and lack of useable farm land or availability of water supply.
- Increased incidence of skin cancer, cancer deaths, cataracts and immune system depression as a result of increased UV radiation associated with upper atmosphere carbon dioxide and ozone interactions.

B. Indoor Smoke and Health

According to the WHO, 2.7% of the global burden of disease is caused by indoor air pollution. The source of this disease catastrophe is the indoor burning of solid fuels in open fire places for cooking and heating. Estimates are that 2-3 billion people worldwide, half the global population, depend on wood, peat, animal dung, straw or other compacted carbon-rich agricultural waste (biomass fuels) and coal (fossil fuel) as their energy supply. These fuels produce indoor levels of carbon monoxide, carbon dioxide, soot, and fine particulates that frequently exceed air quality guidelines 20-fold.

Use of solid biomass fuels is traditional and to a degree practical. Alternative clean burning fuels are frequently not available or too expensive. Fire wood and other biomass fuels, while harder and harder to obtain within easy walking distance of homes, are generally cost-free natural resources. Cooking techniques and cookware are adapted to open fire cooking. Solid fuel cooking also provides warmth for residents during cold seasons.

Solid fuel use is a subsistence issue, hence this indoor air health issue is an issue focused primarily on the world's poorest populations. Women and children have the highest and the longest sustained exposures in the home because the women cook and provide child care and nurture simultaneously. Beyond the health impacts, biomass fuels also sustain a cycle of poverty. The time spent by women searching for fuel prevents them from participating in income generating activities and educational opportunities, which sustains poverty and prevents them from purchasing and using cleaner fuels. Declines in the use of open fire cooking in favor of clean burning gas stoves up until 2000 may now have reversed in favor of more use of biomass fuels (Bruce et al, 2002).

Not only does solid fuel use lead to a range of serious and fatal respiratory diseases, it also depletes the environment of trees and vegetative cover. Deforestation then leads to increased water and wind erosion, arable land loses its capacity to sustain crops and nourish communities, and poverty deepens. Consumed firewood and a lack of carbon fixing trees and plants exacerbates global warming by increasing the release of carbon dioxide and reducing opportunities for it to be fixed as simple sugars by plants. The risks associated with climate change increase.

In general, as prosperity increases, the cleaner the fuel used for heating and cooking. This has been called 'the energy ladder'. While the very poor will use the smokiest fuels (crop waste and wood), slightly better off individuals may turn to available supplies of charcoal or kerosene. Those who are more prosperous will have access to liquid propane or electricity which are the least polluting and contribute the least to indoor levels of harmful pollutants. (WHO, 2000)

Direct Effects

- Increased childhood acute respiratory infection such as pneumonia and otitis media;
- Increased chronic obstructive pulmonary disease and chronic bronchitis in women;
- Reduced birth weight as a result of maternal carbon dioxide exposure;
- Probable causal increase in perinatal mortality;
- Probable causal increase in asthma and tuberculosis;
- Increased risk of cataracts; and
- Increased risk of lung cancer and other cancers.

Indirect Effects

- Increased poverty as mothers are physically less able (or unable) to care for their families due to illness (or death)
- Children are frequently required to replace their mothers for cooking, child care and gathering of fuel and as a result are unavailable for school. This perpetuates the cycle of poverty in these regions as there is a poorly educated work force.